50 years of Observing Plasmas in Space

T. E. Moore

For presentation at the SpaceWeek 2007 in Moscow

Since the pioneering work at the beginning of the space age, we have known that ionospheric plasmas circulate within the ionosphere proper and also within the magnetosphere at high altitudes inside and beyond the plasmapause. Initially, these plasmas were thought to be limited to the lighter ions not bound by gravity to the Earth, and a theory was developed of the plasmasphere and the light ion polar wind that has been largely confirmed by high altitude observations. However, the first plasma composition measurements showed that oxygen ions not only reach high altitudes but also acquire energies comparable to those of alpha particles that most likely originate from the solar wind. Then observations of the auroral zones showed that ions of all masses, including at times molecular species, are heated and accelerated within one Earth radius of the ionosphere proper, enhancing their escape. Diverse processes have been shown to act from the F-region peak on upward through the extended topside, including two main categories: electron heating by soft electron precipitation; and electromagnetic energy flux that drives ions through the neutral gas and heats them resonantly. Recently, these processes have come to be well enough understood that the ionospheric plasma circulation outside the ionosphere proper has been included in global simulation models. From this we are learning that ionospheric plasmas are not only a medium for sinking solar wind energy into the neutral gas of the upper atmosphere. They also expand into the magnetosphere and fill it during active periods owing to large amounts of solar wind energy dissipation into the ionospheric plasmas. Then these plasmas are heated further as they circulate in the magnetosphere. The combination of their density and energy is observed and can now be simulated to create the pressure of the largest storm time ring currents. Thus the dissipation of solar wind energy into the ionosphere ultimately creates a local plasma cloud with enough pressure to inflate the magnetosphere substantially as it seeks to escape from both the gravity of Earth and its geomagnetic plasma trap.